Learn Chemistry

When Your Chewing Gum Loses Its Flavour

Resource Overview

This resource was produced as part of the National HE STEM Programme

National HE STEM Programme

RSC | Advancing the Chemical Sciences

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CONTEXTUAL NARRATIVE FOR TUTORS

Project Summary

Chewing gum has been used by cultures and civilisations since the Neolithic period, thousands of years before Christ. Ancient Greeks and Native North Americans all chewed gum. Today over 28 million people in the UK chew gum regularly. The base gum used nowadays is a synthetic replacement for the original chicle natural product and this is flavoured by numerous extracts, mostly of mint. As with any flavoured foodstuff, occasionally chewing gum flavours produce undesired tastes and odours or other production problems lead to unwanted tastes and textures.

Learning opportunities: The present problem-based learning resource is aimed at helping students to develop approaches which might lead to the discovery of what some of the causes of malodours and tastes in food (gum) are, what properties they might have, to attempt to draw them using computer packages and to use these drawings to calculate their likely chromatographic and spectral properties using modern chemical sciences. The students will also have an opportunity to interpret taste panel and real spectral data.

The present project entailed production of material for the priority area 'Food', (http://www.rsc.org/ScienceAndTechnology/roadmap/priorityareas/food/); specifically, it is related to the subtopic 'Food safety: Provide consumers with 100% confidence in the food they eat' which involves students in researching and learning about the identification and measurement of unwanted tastes and odours in food.

Role of the Tutor

The criteria set by the RSC required that the work align with the definition of Context/Problem-Based Learning made by Savery[3]. Savery defined Problem-based learning as an instructional, learner-centred approach that empowers learners to conduct research, integrate theory and practice and apply knowledge and skills to an *ill-structured problem*. Selection of an ill-structured, often interdisciplinary (or multidisciplinary) problem and the involvement of a tutor, who guides the learning and conducts a debriefing at the end, is considered by Savery to be critical to the success of the approach. The use of the present resource by the tutor and students, therefore, assumes that the characteristics of PBL discussed by Savery, apply.

The resource is planned to be somewhat open-ended and assumes the active involvement of a knowledgeable, experienced tutor. It does *not* attempt to provide detailed instructions or 'answers' to every question that may arise during the exercise, although the powerpoint slides should be sufficiently detailed that relatively little additional background work (if any) is required of the tutor. In 'real-life' research and industrial problems, final 'answers' are often elusive; what it is important is for the learners to develop a problem-based approach which will advance their knowledge of the issues towards a given goal. This can be aided by the tutor, particularly where a sound background knowledge of chemical principles is required of the students but which may be lacking. To some extent, both students and tutor are learners in this kind of exercise.

Assessment

It is assumed that the principles of assessment outlined by Savery[3], apply. Thus, self and peer assessment should be carried out at the completion of the problem (which can effectively be considered a curricular unit for present purposes). According to Savery, the essential characteristic of the assessment should be reflection on knowledge gains. He states that "Students are responsible for the content in the curriculum that they have "covered" through engagement with problems and need to recognise and articulate what they know and they have learned"[3].

The opening session is based on a 'quiz show' type model and uses interactive technology such as Turning Point® (or similar) to provide an opportunity for group feedback and assessment (e.g. via the software which automatically acquires data on numbers of correct answers, etc). Analysis by the tutor, of the correct and incorrect answers to the questions posed in this session, will give a general indication of the depth of reading and pre-searching made by the student body as a whole.

Much of the data and information to be obtained by the students might be compiled in spreadsheet format (e.g. Microsoft Excel® or similar). It is suggested that these are scrutinised by the tutor at regular intervals, possibly at the end of each learning session. Alternatively, students could submit their worksheets electronically to the tutor.

Towards the end of the project, students may be required to give individual presentations and justifications of their suggested solutions to the problem. This presents additional opportunities for individual assessments of the oral contributions of each student, if required.

As a reflective exercise, the beginning of the closing plenary session could be a quiz show similar to the one used in Session 1 using interactive technology (such as Turning Point® or similar) to serve as a diagnostic tool for assessing student learning. A reflective opportunity for group feedback and assessment thus presents itself from an analysis by the tutor of the correct and incorrect answers to the questions posed in this session.

Finally, a full professionally written report of the whole exercise is to be made by each student and assessed as appropriate.

Software and resource pre-requisites

Turning Point® (http://www.turningtechnologies.co.uk/) or similar software is required in order to make the introductory session interactive.

ChemSketch software (http://www.acdlabs.com/download/) is needed for drawing structures of chemicals and for generating SMILES notations and names of chemicals.

As a general reference, Mint:The genus Mentha. Ed. B.M. Lawrence, CRC Press, Print ISBN 978-0-8493-0779-9 ebook ISBN: 978-0-8493-0798-0 is useful.

For Session 4, it is suggested that students conduct a small test of some impregnated filter papers. Suggestions for aroma chemicals to use are given in the tutor slides but clearly these need to be prepared in advance and gloves, tweezers, laboratory coats and safety spectacles provided as deemed necessary.

Tutor Guidance

Session 1. (60 minutes) Introduction to the problem.

In advance of Session 1, and in order that they may answer the quiz questions, or at least make a reasonable informed attempt, students should be asked to read information about chewing gum history, production and processing. The following web sites may be suggested by the tutor by an e-mail memo in advance, but students should also be directed to conduct their own search on the search term ‘Chewing Gum’ in preparation for Session 1. It should also be made clear that students will need this background knowledge in order to carry out the problem-solving elements of subsequent sessions.

Suggested websites:

http://beemansgum.org/history/chewing-gum/
http://www.wrigley.com/global/about-us/ingredients.aspx
http://en.wikipedia.org/wiki/Chewing_gum
http://chemistry.about.com/od/chemistryfaqs/f/chewinggum.htm (all last accessed 18.11.11)

A slide presentation is provided in order that the tutor may outline the nature of the problem to the students in a problem-based, interactive manner. It is suggested that the slides provided be converted to a 'clicker-based' interactive presentation using Turning Point® (http://www.turningtechnologies.co.uk/) or similar software so that the quiz is more instructive and entertaining for students and so that histograms of the answers are produced. As such, the quiz can act as a diagnostic test of students' background knowledge. It may be of particular interest to observe any differences between students' general knowledge versus that which is more chemistry-specific. Answers given in the presentation provided contain information, which may be used to encourage students to engage in further reading (e.g. references to general scientific articles in *Nature* and more specific research papers). This may also inform the quiz in the final session, if this approach is adopted.

Sessions 2-4

The resource is then further developed as a series of instructions and encouragements, plus additional data, provided in the form of Power Point slides. Two versions are available, one with student notes and one with student plus tutor notes (the latter indicated with a 'T'). Students are encouraged to make an on going, progressively improved, spreadsheet (with back-ups) of all of the data that they can assemble in their attempts to address the problem.

The divisions into sessions 2-4 are entirely arbitrary and intentionally unequal in length. Tutors can subdivide the work as required or as judged from the rate of progress and the experience and abilities of the students. Some further guidelines on this are given with some of the slides.

For Session 4, it is suggested that students conduct a small test of some impregnated filter papers. Suggestions for aroma chemicals to use are given in the tutor slides but clearly these need to be prepared in advance and gloves, tweezers, laboratory coats and safety spectacles provided as deemed necessary.

Session 4 also comprises a set of guidelines to be given to students to enable them to structure their final report. It is probably worth clarifying the 4 key criteria using some tangible examples, especially as the reporting format is unlikely to appear standard for most students. In Session 4, it is recommended to provide feedback on the assessed reports and either give another quiz similar to that used in Session 1 and/or give a plenary Power Point-style lecture which focuses on the key learning outcomes and likely draws on some of the supplementary literature provided through the tutor notes**.** The plenary lecture can produced from the current research literature by the tutor in order to keep apace with more recent developments.

Intended audience

The resource was developed with first and second year honours undergraduates in chemistry, in mind. However, it is difficult to gauge exactly the level of audience for whom this resource might prove useful. A degree of knowledge is expected in fundamental chemical concepts and some prior knowledge of analytical techniques such as infrared spectroscopy and mass spectrometry is also desirable. However, where this knowledge does not already exist, students can be encouraged and allowed time to seek such information as part of the exercise. It is hoped that the desire to solve the problem will prove sufficiently inspiring to encourage the self-learning needed to make a reasonable attempt to learn about the techniques needed. It may prove possible to extend use of the resource to undergraduates in other subjects, particularly food science or human nutrition.

Feedback from piloting

Tutor feedback:

In general, the tutors who piloted this resource agreed that it provided a useful learning experience for their students. It was stated that some difficulties were encountered with larger class sizes and that groups of 20-40 were probably optimal. In addition, one tutor found it necessary to modify the structure of some of the sessions so that they were more equal in length (see the end of this narrative for an alternative structuring) and this was quite time-consuming. A further tutor also needed to spend quite a bit of time planning their own schedule and that of the students. Thus, it should be emphasised that the suggested timeline is only indicative and should be modified where necessary. In addition, tutors should expect to invest some time up-front when preparing to use this resource.

Tutors stated that the students appeared to enjoy the research element of the work and that an element of competition between the groups provided students with additional motivation. That said, one tutor stated that it also provided an opportunity for less confident students to play a significant role. The initial session involving the electronic voting was found to be particularly popular. The resource was found to be particularly effective in developing group working skills, not least because of the homework tasks that had to be completed between timetable sessions. Completion of the homework tasks was generally very good and this was attributed to the students being motivated by the investigation. The tutors also believed that the resource gave the students valuable experience in tackling and solving 'real-world' problems.

Finally, tutors recognised that the role of the tutor and style of teaching, in general, were somewhat different to those normally associated with traditional teaching and, as such, some tutors might require some investment of time and possibly further guidance or training. It was also suggested that alternative assessment strategies might be used, including the use of both group and individual reports.

Student feedback:

Student feedback was very positive and students found the resource fun and educational. There was unanimous agreement that the experience had given them better team working and researching skills, as well as furnishing them with practice in solving real-life spectral problems and providing them with greater chemical understanding and knowledge of organic chemistry. Several students, however, expressed concerns about the amount of time that they had to invest in researching information, especially when they had other deadlines to meet for assessed work.

In one case, some quantitative (average) student feedback scores were obtained:

Enjoyment and relevance of the unit - 4.5/5
Appropriateness of resources - 3.7/5
Effectiveness of team working and improvement of team working skills - 4.5/5
Time management and time allowed to cover tasks - 4.8/5

References

1. http://www.rsc.org/ScienceAndTechnology/roadmap/
2. http://www.energy.alberta.ca/OurBusiness/oilsands.asp
3. Savery J. R. (2006). Overview of Problem-based Learning: Definitions and Distinctions. *The Interdisciplinary Journal of Problem-based Learning*, **1**, 9-20.

Alternative schedule (suggested from pilot phase)

Session 1.
Homework: Spend 30 minutes finding out everything possible about chewing gum.
PowerPoint: Individual electronic voting quiz.
Plenary: Led by tutor discussing facts learnt from homework task and quiz.
Powerpoint: Introduction of the problem, taste panel results, taste panel analysis.
Group discussion, research, results and conclusions.

Session 2.
Homework: Spend 30 minutes finding out everything possible about electrospray ionisation mass spectrometry (positive and negative mode) and make a list of chemicals found in chewing gum and their relative molecular masses.
Plenary: Led by tutor discussing what was learnt from homework; pooling of data.
PowerPoint: Introduction of the ESI mass spectra (problems discussed elsewhere).
Group discussion, research, results and conclusions.
Research task, EI-MS, GC-MS, chromatography, followed by analysis of EI-MS and GC-MS.

Session 3.
Homework: Spend 30 minutes finding out everything possible about natural flavourings.
Plenary: Led by tutor discussing facts learnt from homework task, natural flavourings.
Group work: Provide flow diagram of tasks so far.
PowerPoint: Introduction of flavourings.
Research task: Separation methods for volatiles, internal standards, column chromatography.
Plenary: Sharing of information and discussion; interpreting IR data.

Session 4.
Homework: Spend 30 minutes finding out everything possible about column chromatography.
Plenary: Led by academic discussing facts learnt from homework task.
Group work: column chromatography (*some students felt the exercise on creating method for column chromatography by listing numbered statements from PowerPoint slide was unnecessary). Analysis of GC and EI-MS of GC component.
PowerPoint/Plenary: Separation methods, column chromatography, analysis of GC and EI-MS of components.
Research: Chirality and biological activity.
Group Work: Summarise problem, your potential solution and what experiments you would need to conduct to confirm your theory.
Plenary: Academics summary and potential solution.

Specific student feedback comments

Experiences of C/PBL

“It was good because it was something I'd have never really thought chemistry played a big part in and it allowed me to broaden my horizons and think how chemistry is used in other areas which you wouldn't initially think of. It also allowed us to see and understand some of the other spectroscopic methods, instead of the more common IR and NMR spectroscopy.”

“Overall the exercise was entertaining and very interesting as it gave me insight into other areas of chemistry past the obvious in pharmaceuticals and the petroleum and chemical industries. It was nice to work as part of a team as opposed to the mainly individual work of university.”

“I enjoyed taking part in the course as it was very engaging and required us to work as a team, an experience which is invaluable in future life. However, I did feel the problem could have had a wider range of chemistry in it so the students taking part in the course could gain the most out of it.”

“I thought the experiment was great and I enjoyed the whole experience. I would definitely recommend it to other students.”

“In my opinion the context/problem based learning format was extremely useful in terms of learning, but also understanding what I was learning more effectively.”

“Overall, the experience of the PBL task allowed a relaxed investigation into an area that would not usually be explored.”

“Personally I feel that the context/problem based learning is a useful skill which I have acquired, which will continue to help my learning throughout my degree.”

“On a non-scientific level, I have learnt a great deal about problem-based learning, a way of learning that I hope to be taking part in during future education.”

“I believe that incorporating PBL into routine course learning would be very beneficial to any student.”

“I think a combination of information delivery in lecture form and ‘homework’ for each module could be the way forward.”

“I believe problem based learning can be used in cognition with the classic lecture style teaching. It should be used to enhance the students learning of a subject, although all people learn in different ways.”

Achievements through problem solving

“I thought it was an interesting project that provided me with a new insight into different analytical techniques and how they can be used to solve a real world problem.”

“This experience has also been advantageous in giving me a true insight into how analysis is carried out in industrial settings. It has shown how it is important to only use techniques that are appropriate to the task in hand and how costly analysis can become. I am now more aware of how problem solving is tackled strategically in a step by step process in order to give the best outcome.”

“I found that I enjoyed researching and locating information. I found it more rewarding to discover evidence that supports theories in my mind, than being fed from a lecturer.”

“I have learnt more using this method than if it were purely lecture delivery. By being assigned tasks to complete including research, I have read around the subject rather than focus on lecture notes.”

“It was a good opportunity to experience the sort of processes that food companies would go through to discover the reasons behind any reported problems in the products. It was also a good opportunity to work in a team and to take a further look at a few types of spectroscopy.”

Project resources:

“The resources delivered have a good standard of background knowledge and scientific information.”

“Awareness of mass spectrometer, gas chromatography and Soxhlet extraction are shown on the lecture slides but also leaves scope for further research and subsequently for better understanding.”

“I found the statistical analysis task riveting. This may have been because we actually performed the analysis on the given data, with the aid of our tutorials, of course.”
“All tutorials were very informative and well constructed.”

“The resources were good as the problem was interesting and the information given was just enough for the problem to become engaging. However, some of the resources seemed to be badly thought out, I seem to remember there being some peaks nobody could assign.”

Pace of learning:

“I was assigned task sheets to complete each week. This helped me a great deal when it came time to write assessed essays as the information I had learnt at home had been retained.”

“In a lecture, which is roughly about an hour and a half, I feel sometimes that my concentration fades, yet with the C/PBL you are free to spend as little or as much time as you wanted on it. It was also good that as a group we met once a week to discuss our findings and how we were getting along with the project.”

“I have learnt that there is not always a fast, straightforward solution when solving real-life problems and there may be many steps in finding an answer.”

Problems/difficulties/barriers:

“The report itself was much longer than I anticipated. I found this a little excessive because we also had essays and lab reports due in at the same time and I struggled to keep up. As the weeks went on, I found that the tasks got harder and longer and near the end, I struggled to understand a lot of the work and simply could not keep up.”

“The only problem I feel that I faced personally, was that I would have liked to have spent more time on the tasks given, however with coursework and exams looming I had to be very self-disciplined with my time.”

“I found that occasionally I was wondering away from the field I was meant to be learning about, for example because I have previously learnt about gas chromatography in an analytical methods module, I found myself looking at the more advanced techniques and ignored the basic principles, moving further away from what was needed for the project.”

“Self-discipline was probably the hardest aspect of the course.”